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Expeller vs. Solvent Process

LINSEED OIL MEAL

FOR MILKING COWS

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SOLVENT vs EXPELLER PROCESS LINSEED OIL MEAL FOR MILKING COWS

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LITERATURE REVIEW

For many years practical feeders have shown a decided preference for linseed oil meal by paying more per pound of protein than for other protein concentrates. Recent development of a method of extraction with hexane and other solvents capable of reducing the fat content from a range of 5 to 7 percent down to 0.5 percent has caused feeders to question whether linseed oil meal will in the future be as valuable as it formerly was. Barton and coworkers (1) stated that "Quite aside from its animal nutrient content, this product is one of the most beneficial known for toning up rundown animals and producing a 'bloom' on stock. It is also laxative and cooling to the digestive system, which fact adds another sphere of usefulness to its credit." Iowa workers (2) concluded "Linseed meal is one of the few feeds in which the protein content cannot be employed as a definite criterion of feeding value. This feed possesses advantages not measurable by chemical analysis."

Linseed oil meal has found wide use for all classes of livestock. Willams and Ellis (3) found it valuable as a conditioner for horses. Black (4) observed that "Hogs following cattle fed linseed meal do much better than those that follow cattle fed cottonseed products". Helmer Rabild, H. P. Davis and W. K. Brainerd (5) in feeding dairy cows found that linseed oil meal "Has, however, a distinctive place in a mixture in supplying protein, to increase the palatability, and improve the physiological effect." Woodward, Shepherd and Graves (6) compared cottonseed and linseed oil meals for calf feeding and concluded that "It appears therefore that cottonseed meal contains some substance that linseed meal does not, which is detrimental to the calves." Rommel (7) found that pigs gained more rapidly on hominy chop and linseed meal than on hominy chop plus gluten meal.

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[1]Now Agricultural Representative for the Wayne County National Bank, Wooster, Ohio.

Old process linseed oil meal contained from 5 to 7 percent fat and was highly regarded because of the energy which this fat yielded. Development of the expeller process reduced the fat content of the meal after which many feeders specified "old process" meal because they felt that a certain level of fat in the ration was necessary and linseed meal was one of the readiest sources of fat. Further refinement achieved in 1949 by continuous extraction with hexane, a fat solvent, has reduced the fat to as low as 0.5 percent. Maynard, Loosli, and McCay (8) fed two groups of cows limited timothy hay and corn silage as roughage. The dairy feed mixtures varied in the fat percentage of the protein concentrates. The low fat ration contained 110 pounds of starch per ton to reduce the protein content of that ration to the protein content of the other ration. The high and low fat rations contained approximately 7 and 3 percent fat, respectively. The cows fed the high fat ration yielded 4 percent more milk. It is known that starch depresses digestibility and this fact may account for the difference in production. Monroe and Krauss (9) did not find significant differences in milk or butterfat production when extracted soybean meal replaced expeller process soybean meal in practical dairy rations. That the difference in production in the experiments of Maynard and coworkers (8) was due to differences in available energy rather than to fat **per se** appears probable as later work by Loosli, Maynard and Lucas (10) demonstrated that small amounts of hay compensated for the extra energy of the high fat ration.

Thalman (11) fed for 184 days, two lots of 10 heifer calves each, whose average weight was 406 pounds. Corn silage and cracked corn furnished the energy. Ground limestone, steamed bone meal, and salt were supplied. One lot was fed 1.5 pounds old process linseed meal (4.67 percent fat) daily per animal while the other lot was fed 1.5 pounds solvent extracted linseed oil meal (1.41 percent fat). He stated "There was no appreciable difference between the two lots in the amount of feed consumed, in rate or economy of gain, or in market desirability as judged by selling price and slaughter data". Understanding of this failure of fat to produce extra gains may be clarified by the experiments of Hale, Duncan and Huffman (12) on digestibility of alfalfa hay. They concluded that there was an actual increase of fat in the rumen probably due to synthesis of fat by microorganisms.

Evidently there must be some constituent of linseed oil meal other than fat which imparts the desirable characteristics. The Iowa workers (13) expected that "The factor, or factors, responsible for high finish or 'bloom' in cattle fed linseed meal may be 'tied up' with the unsaturated fatty acids in the oil". They fed unsaturated fatty acids from flax seed and crude linseed oil respectively as supplements to a basal ration containing solvent extracted linseed oil meal without causing improvement in the experimental animals over that of animals fed solvent extracted meal without added oil. They concluded "From the results of this one trial it appears that the new process linseed meal without added oil was as effective as the old process linseed meal in promoting finish".

In a review article Hayward (14) stated that "It is believed that the mucin or mucilaginous substance in linseed oil meal is responsible for this property—at least, we are quite sure that the conditioning properties of linseed oil meal are not due to its fat or oil content".

Feeders who have traditionally used linseed oil meal for its conditioning quality naturally want to know the effect of solvent extraction on the palatability of the ration. Allen (15) found "no practical difference in palatability of the expelled and extracted meals when used in a dairy cow ration at the level of 28 percent".

EXPERIMENTAL

An experiment to further investigate the difference between expeller and solvent extracted linseed oil meals was carried out in the Department of Public Welfare herd at the Mansfield State Reformatory at Mansfield, Ohio. This herd consisted of 120 milking Holsteins and sufficient animals were found in early stages of lactation to make satisfactory experimental groups.

Plan. Two experimental groups were given dairy rations in which the only planned difference was the kind of linseed oil meal contained: one contained expeller process linseed oil meal; the other contained solvent extracted linseed oil meal. The grain mixture was fed at the rate of one pound for three pounds of milk produced, to give maximum opportunity for the influence of the oil meal to exert itself upon milk production and physical condition. The other constituents of both grain mixtures came from a common source. Both groups were also fed from a common source of alfalfa hay and silage and although it varied from week to week both experimental groups were affected alike. The ten experimental periods were of 10 days each. There were two preliminary periods when all the cows were fed a grain mixture with equal parts of the two linseed oil meals blended. At the close of these preliminary periods the animals were divided into two groups balanced equally in all respects. Each group received the grain mix with its respective linseed oil meal for a transition period and ten successive 10-day periods. Two such feeding trials were conducted in each of which the cows had as much roughage as they would eat. Thus

TABLE 1.—Pounds of 4% (F.C.M.) milk produced daily by 10-day periods, 1st trial

Cow No.	Preliminary 1	Preliminary 2	Transition 1	Experimental Periods 1	2	3	4	5	6	7	8	9	10
Solvent Extracted Linseed Oil Meal													
726-A	42.5	48.4	60.8	51.1	45.0	45.5	41.9	43.6	38.6	40.9	47.9	38.5	44.5
1333	74.8	78.9	63.8	52.0	46.6	55.5	51.0	61.0	49.7	47.3	50.5	51.4	56.5
115	58.8	60.0	53.4	53.1	42.2	41.5	39.6	37.6	33.6	33.9	35.8	36.3	34.8
409-A	51.2	58.6	48.8	47.2	47.5	50.7	54.2	50.0	51.4	43.7	44.4	48.0	50.6
1247	52.8	39.5	40.4	35.9	34.5	33.8	33.3	30.7	29.4	30.3	27.7	31.1	34.9
708-A	31.3	34.6	32.6	31.2	33.1	31.9	32.2	33.2	31.5	33.4	30.8	34.2	36.5
425-A	42.7	46.8	41.7	41.5	42.3	38.5	38.4	40.3	37.9	33.9	35.4	39.5	39.9
727	28.0	37.3	43.5	40.7	44.9	36.6	39.9	35.6	37.5	37.3	37.1	40.3	40.3
618-A	36.3	31.1	34.4	27.0	29.5	27.4	25.5	23.7	22.8	21.3	22.7	21.1	21.6
H-150	26.2	26.8	25.1	24.3	24.0	21.7	23.1	21.8	22.4	21.6	24.3	22.8	22.9
H-148	29.6	31.1	30.4	28.0	27.5	26.9	25.9	26.9	23.7	22.4	22.5	24.5	26.5
H-151	44.4	43.6	46.2	41.9	38.7	41.3	41.0	39.6	38.6	36.6	38.0	39.4	40.0
551	29.8	27.1	28.5	25.8	25.7	24.3	23.4	22.2	19.8	20.8	22.5	20.7	22.4
Ave.	42.2	43.3	42.3	38.4	37.0	36.6	36.1	35.9	33.6	32.6	33.8	34.4	36.2

Expeller Process Linseed Oil Meal

716	38.6	41.5	46.9	42.6	47.6	44.4	44.0	45.7	42.1	41.1	44.7	43.3	45.9
146	52.3	65.6	62.1	54.5	48.0	50.5	47.1	43.8	39.5	40.8	37.3	42.5	47.7
1347	55.1	43.1	39.8	43.7	42.7	39.2	35.2	37.7	34.8	31.4	32.0	31.6	31.2
447-A	48.9	44.3	41.6	34.7	36.7	37.6	33.2	32.8	31.4	32.2	33.1	28.5	30.1
432	46.0	48.6	42.1	44.3	43.0	41.8	36.0	34.4	33.9	30.6	31.3	32.7	36.9
1323	29.0	27.8	30.1	25.7	27.0	25.4	25.4	26.6	25.6	26.0	24.6	25.3	25.6
1360	45.3	45.5	45.7	41.6	44.2	38.8	42.2	39.0	40.4	33.3	35.8	35.9	32.4
T-496	23.2	26.9	25.8	24.5	24.7	23.5	22.9	24.8	22.7	21.7	22.8	21.8	23.4
625-A	39.0	41.3	47.2	43.9	45.8	42.0	45.9	41.6	39.3	38.1	43.0	41.0	42.8
632-A	35.2	36.4	34.9	34.5	28.9	31.8	32.4	32.2	31.8	29.8	31.9	29.7	32.7
627-A	38.0	39.3	36.3	37.1	35.6	34.5	33.8	35.6	32.9	30.2	31.2	27.2	29.7
M-728	45.8	43.4	42.7	40.1	39.0	38.5	40.2	37.5	39.5	35.7	40.2	34.6	40.8
H-102	52.4	55.8	53.0	53.0	51.1	50.0	44.3	48.2	46.5	44.3	39.3	35.3	38.3
Ave.	42.2	43.0	42.2	40.0	39.6	38.3	37.1	36.9	35.4	33.5	34.4	33.0	35.2

the extra energy of the additional oil of the expeller meal could be compensated by consumption of more roughage by the group receiving extracted meal.

Experimental Design. Two continuous feeding trials were conducted. Thirteen pairs of cows were used in the first trial and twenty-five pairs in the second.

These cows were divided into two experimental groups of which one group was fed expeller linseed oil meal and the other was fed solvent extracted linseed oil meal.

They were fed for two 10-day preliminary periods to provide a basis for division into two experimental groups. The transition period gave an opportunity for the rumen process to become stabilized. Comparisons of milk production were made during ten 10-day experimental periods.

Animals. Twenty-six Holstein cows averaging 1300 pounds in weight were divided into pairs on the basis of age, weight, stage of lactation and milk production. The pairs were distributed between two groups so as to give comparable groups. Figure 1 shows the type of mangers that was used.

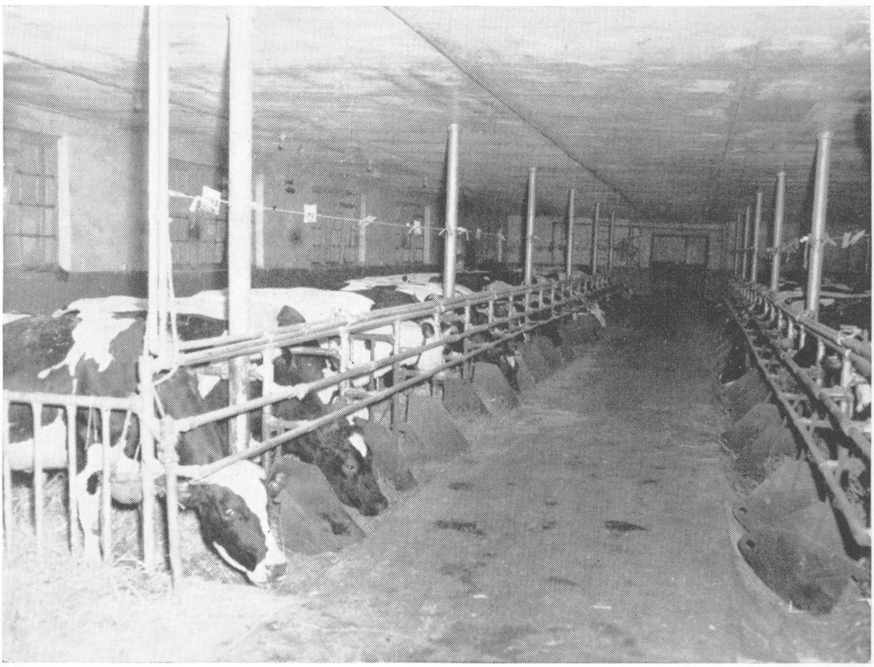

Fig. 1.—This illustration shows a group of the cows that were used in the tests of linseed oil meal. The type mangers from which they were fed are shown too.

Rations. The linseed oil meals used for the first feeding trial (January 19 to May 28, 1950) showed the following compositions:

	Linseed Oil Meal	
	Expeller	**Solvent extracted**
Moisture, %	7.72	8.44
Protein, %	34.21	36.59
Fat, %	4.43	1.34
Fiber, %	9.79	9.27
Manganese, p.p.m.	23.00	22.20
Thiamine, p.p.m.	2.22	5.30
Riboflavin, p.p.m.	4.27	2.72

These linseed oil meals[2] were combined with the other ingredients in the following proportions:

Ground shelled corn	400 pounds
Ground oats	240 "
Wheat bran	100 "
Linseed oil meal	250 "
Iodized salt	10 "

The two rations fed during the first feeding trials analyzed as follows:

	Mixture containing Expeller Meal	**Mixture containing Solvent Extracted Meal**
	%	%
Moisture	16.67	16.66
Protein	17.66	18.05
Fat	3.33	2.54
Fiber	7.61	6.69
Ash	4.86	4.39

[2]We are indebted to the Linseed Oil Meal Council for both Expeller and Solvent Extracted meal **of known origin** from the mills of Archer-Daniels-Midland Company, and to Archer-Daniels-Midland Company for these analyses.

The second feeding trial involved 25 pairs of animals which were fed from October 28, 1950 to March 6, 1951. The plan was the same as outlined for the first trial. The only notable difference in the linseed meals was that the solvent extracted meal contained only 0.84 percent fat. The mixture containing solvent extracted meal analyzed 3.42 percent fat while the mixture containing expeller meal analyzed 4.35 percent fat. Before each feeding trial enough of both kinds of linseed meal was obtained to feed through the entire trial. Aliquots of each grain mix for a trial were composited for analysis. Both hay and silage were fed. Sufficient hay could not be stored to last through the trials. As a consequence the hay varied but both groups were fed hay from the same source. Both grass and corn silages were fed but again the two groups were always fed alike. Manger dividers were used and effectively prevented the cows from stealing silage and grain but would not prevent interchange of hay. Therefore, no record was kept of the amounts of hay fed—sufficient hay was fed so that all cows were able to eat to capacity.

EXPERIMENTAL RESULTS AND DISCUSSION

FIRST FEEDING TRIAL

The milk production of both groups is shown in Table 1 by 10-day periods. The actual pounds of milk and fat have been converted to an amount of 4 percent milk ($0.4 \times$ lbs. milk $+ 15 \times$ lbs. fat $=$ lbs. 4 percent milk) that would contain the same amount of energy. It will be noted that the division of animals into groups at the close of the transition period gave very similar production for the two preliminary periods also. Careful analysis of the data shows temporary fluctuations as the trial progressed. When these data are plotted, the lactation curves (Fig. 2) show no apparent increase of one group over the other. The group receiving solvent extracted linseed oil meal produced a pound of 4 percent milk for each 0.41 pound of grain eaten while the group fed expeller meal produced a pound of 4 percent milk for each 0.42 pound of grain eaten. Clearly no practical difference in the value of the two oil meals is evident.

The animals were observed carefully for differences in condition of the feces and hair coats of the two groups, but no consistent differences were evident.

SECOND FEEDING TRIAL

The milk production for the second feeding trial is presented by 10-day periods for both groups in Table 2 and has been plotted in Figure 2. The average daily milk production at the transition period indicates that the groups were well chosen. There is a definite trend toward higher production from the group fed solvent extracted meal. To determine whether the differences are significant standard deviations were determined for both trials separately and for the combined trials and are presented in Table 3. The larger standard deviations for both groups of the second trial than for the first are due to a greater variation in the amount of milk produced by individuals within the groups. The small degree of change in standard deviations as the trial progressed indicates that the variations within the two groups did not increase due to conditions of the experiment. To test the reliability of the data, the "t" test was applied and neither in the first nor the second trial did the differences in production of the two groups approach significance at the 1 percent level, signifying that if this experiment were repeated 100 times the results would be the same 99 out of the 100 times. The data

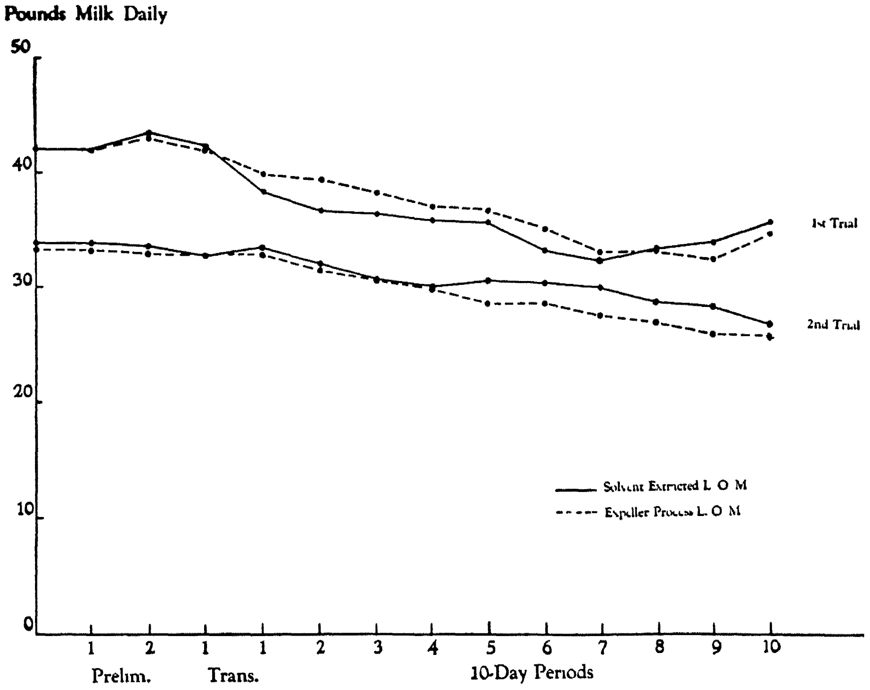

Fig. 2.—Milk production during the second period has been plotted in this graph. As the test progressed, there was a trend toward higher production from the group receiving solvent extracted meal.

TABLE 2.—Pounds 4% (F.C.M.) milk produced daily by 10-day periods, 2nd trial

Cow No.	Preliminary 1	Preliminary 2	Transition 1	Experimental Periods 1	2	3	4	5	6	7	8	9	10
Solvent Extracted Linseed Oil Meal													
741-A	56.2	52.3	53.8	56.2	45.5	45.9	49.9	46.0	46.8	48.5	43.0	45.8	44.1
800	23.7	23.7	22.1	21.5	21.3	21.7	21.6	21.6	21.6	22.4	23.3	22.8	18.9
H-149	25.1	25.0	23.7	24.6	23.6	23.6	24.1	22.5	21.8	21.0	20.5	21.2	22.0
1396	32.7	32.4	34.3	33.2	30.9	31.9	29.9	28.0	29.4	29.6	29.1	29.1	26.6
1354	37.0	33.4	33.2	32.5	30.8	29.3	29.2	27.5	29.2	30.1	28.8	29.4	28.0
707-A	25.9	28.1	28.0	27.2	26.8	23.2	21.6	24.0	24.4	23.3	21.7	20.7	19.6
806	27.4	28.6	29.2	31.3	27.6	30.0	26.3	29.3	28.7	25.7	27.0	25.7	25.1
1234	47.0	38.5	30.2	37.7	37.9	34.7	33.7	34.1	31.0	32.8	29.7	32.1	28.6
974	35.7	37.2	37.6	36.7	34.6	35.6	33.9	32.9	34.2	32.0	28.6	25.9	25.8
744-A	25.3	24.7	21.2	23.4	21.5	21.0	21.9	21.3	21.4	22.4	21.7	22.2	20.5
803	36.0	37.5	37.9	36.9	29.2	33.8	34.3	37.2	37.7	35.6	33.9	29.6	27.8
819-A	33.1	34.5	35.6	36.3	34.2	33.8	32.5	35.7	32.0	32.2	30.9	33.5	30.6
739	27.4	28.9	26.9	28.9	28.3	26.7	25.1	28.7	27.1	27.8	27.5	26.7	26.3
728-A	31.2	33.3	31.0	31.0	31.3	30.4	32.2	30.0	30.2	30.6	27.3	25.1	28.1
705-A	24.1	23.7	23.0	24.1	23.2	22.3	23.7	22.9	22.9	23.8	22.7	23.1	22.5
1372	26.6	25.8	24.7	24.7	23.1	21.9	21.4	22.3	20.0	19.5	20.0	18.7	17.7
808-A	26.2	25.4	25.1	27.1	25.2	23.9	25.2	25.3	25.7	23.0	24.2	22.7	19.9
71	48.2	27.6	50.0	48.7	49.9	46.4	44.4	43.3	43.6	42.9	43.4	43.1	37.3
708-A	33.4	40.2	42.7	45.7	41.6	39.6	38.1	38.7	38.1	36.9	35.7	32.6	32.0
M-724	38.6	39.9	42.3	36.9	35.8	32.7	35.1	34.6	32.6	31.3	32.1	31.1	31.1
700	31.5	32.2	31.4	30.8	28.5	27.8	28.5	28.1	28.4	27.4	26.4	26.2	24.3
627-A	45.0	43.9	40.5	43.2	40.3	40.8	41.2	43.6	43.4	43.5	40.0	42.7	40.6
716	29.3	29.9	28.1	29.1	28.3	27.5	24.0	29.1	28.4	27.8	25.3	23.9	22.4
632-A	49.8	45.3	45.4	45.0	45.8	46.0	41.8	44.5	44.2	42.9	44.4	44.7	44.7
125	30.2	28.2	25.4	26.1	24.7	24.9	21.9	24.6	25.7	27.4	25.1	23.3	22.6
Ave.	33.9	33.6	32.9	33.6	31.6	31.0	30.5	31.0	30.7	30.4	29.3	28.9	27.5

Expeller Process Linseed Oil Meal

T-475	42.1	41.3	37.5	35.9	34.4	37.3	37.6	33.6	31.6	29.0	27.2	25.8	25.0
738	24.9	26.1	24.3	23.5	23.9	22.2	24.9	22.5	22.0	23.9	23.7	24.3	23.2
617	27.3	27.6	25.7	25.7	23.0	22.9	23.8	21.5	21.5	20.9	21.2	20.3	21.9
139	27.8	27.2	27.7	27.6	27.1	26.5	23.5	22.1	26.7	24.2	23.8	25.2	23.5
M-727	35.8	36.1	35.9	34.1	33.4	29.6	37.2	29.9	29.6	30.4	28.1	25.9	24.0
719-A	28.4	29.3	29.2	26.3	27.9	27.3	28.1	25.5	26.6	25.5	26.9	26.7	27.5
740	31.6	32.9	33.4	33.7	32.6	31.7	30.2	32.0	32.9	33.2	30.3	32.9	32.2
731	27.4	27.3	27.3	26.8	25.5	26.0	21.5	23.9	23.3	22.1	20.9	20.1	18.7
818-A	40.7	34.1	35.2	36.0	34.0	35.2	33.7	31.7	32.2	30.0	31.7	31.7	31.7
804-A	26.5	25.6	25.0	25.0	24.5	23.0	23.0	22.8	22.1	20.2	21.5	21.4	19.2
628	29.8	29.6	28.9	28.7	27.3	24.8	27.2	24.1	22.4	21.3	22.9	23.6	27.0
H-102	26.1	22.8	23.4	23.5	25.5	23.6	25.3	24.0	23.5	22.4	22.5	22.3	21.7
1411	63.6	61.9	66.7	67.2	54.4	56.1	55.4	43.8	42.8	39.3	36.1	34.3	32.6
985	34.4	33.4	36.8	34.4	33.4	31.8	29.7	28.7	28.7	26.9	24.8	22.2	20.3
717-A	37.5	44.0	45.6	47.2	44.0	42.7	42.2	40.2	42.0	40.0	38.7	36.8	37.1
702	39.4	38.2	39.3	36.5	38.8	37.5	37.8	38.4	38.6	38.8	38.6	37.3	38.3
619	26.8	27.1	28.0	27.0	27.2	26.8	24.2	25.3	24.3	23.1	21.6	18.9	19.4
607	39.5	38.9	34.9	36.7	32.6	30.8	29.1	32.3	32.6	30.4	28.0	27.2	29.1
832-A	44.2	47.4	52.0	55.0	48.6	51.4	49.0	50.8	51.0	50.5	50.7	47.3	48.1
814	31.3	30.3	27.1	34.0	33.9	30.3	29.9	28.6	29.0	27.0	27.9	25.2	29.2
1319	34.6	38.0	35.7	38.3	36.3	39.1	34.7	32.2	33.5	34.3	31.7	30.7	30.0
622-A	24.5	22.9	20.8	22.5	22.0	21.1	16.3	18.5	20.8	20.3	19.5	19.2	19.7
727	30.4	29.7	28.9	28.9	29.5	27.9	24.2	24.6	24.5	25.0	24.1	22.5	19.5
L-624	22.6	22.1	21.4	21.2	22.0	19.9	19.4	19.0	19.7	18.7	18.9	19.6	17.0
815-A	34.5	34.1	33.0	30.3	30.0	26.3	26.8	27.4	27.2	27.6	27.6	27.3	27.4
Ave.	33.3	33.1	32.9	33.0	31.7	30.9	30.2	28.9	29.2	28.2	27.6	26.7	26.5

of the combined trials represents 38 animals per group. The daily production per animal and the standard deviation (or degree of variation) for the two groups is concordant and justifies the conclusion that there is no actual difference between the two oil meals for milk production.

The average butterfat percentage for the 25 cows fed solvent extracted linseed oil meal was 3.28 percent over the entire 100 days of experiment and 3.31 percent for those fed expeller linseed oil meal. Clearly this difference is not an important one and is probably due to chance in selection of the groups.

Figure 3 shows a cow typical of the group receiving solvent extracted linseed meal and indicates that very complete removal of the fat does not reduce the conditioning effect for which linseed oil meal is noted.

The average grain consumption of the solvent extracted- and expeller-fed groups was 12.26 and 11.89 pounds respectively daily which was 0.40 pound and 0.41 pound respectively per pound of 4 percent milk produced.

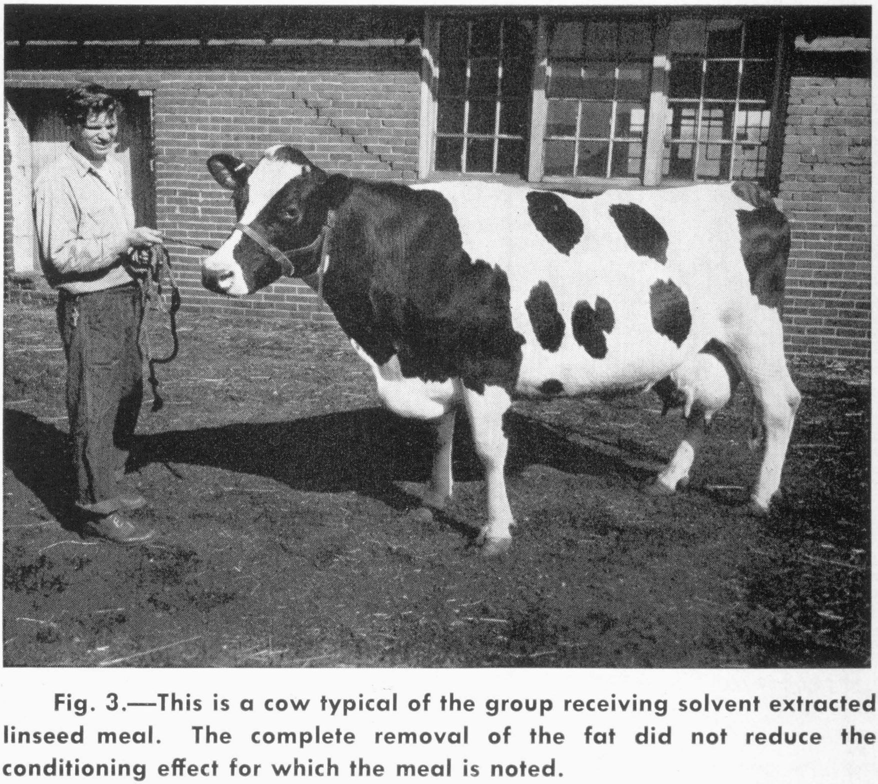

Fig. 3.—This is a cow typical of the group receiving solvent extracted linseed meal. The complete removal of the fat did not reduce the conditioning effect for which the meal is noted.

TABLE 3.—Average Daily Milk Production and Standard Deviation by Periods for Cows Receiving Solvent Extracted and Expeller Process Linseed Oil Meals

Periods	First Trial Extracted	First Trial Expeller	Second Trial Extracted	Second Trial Expeller	Combined Trials Extracted	Combined Trials Expeller
Preliminary						
1	42.2±4.5	44.1±3 0	33.9±9.0	33.3± 8.7	36.7±11.6	36.3± 9.8
2	43.3±4 8	43.0±3.3	33 6±8.0	33.1± 9.0	36.9±11.7	36.5±10.4
Transition						
1	42.3±3.9	42.2±3.0	32.9±8.9	32.9±10.2	36.1±11.0	36.1±10.8
Experimental Periods						
1	38.4±3.3	40.0±2.8	33.6±8.8	33.0±10.6	35.2± 9.6	35.4±10.4
2	37.0±2.7	39.6±2.6	31 6±8.8	31.7± 8.1	33.5± 8.5	34.4± 8.9
3	36.6±3 3	38.3±2.6	31.0±7.9	30.9± 9.1	32.9± 9.0	33.4± 9.4
4	36.1±3 2	37.1±2.4	30.5±8.0	30.2± 9.1	32.4± 9.0	32.6± 9.2
5	35.8±3.6	36.9±2.2	31.0±7.7	28.9± 7.9	32.7± 9.3	31.6± 8.4
6	33.6±3.2	35.4±2.2	30.7±7.7	29.2± 7.8	31.7± 8.6	31.3± 7.5
7	32.6±2.8	33.5±2.0	30.4±7.7	28.2± 7.7	31.1± 8.1	30.0± 7.6
8	33.8±3.2	34.4±2.0	29.3±7.2	27.6± 7.3	30.8± 8.3	29.9± 7.7
9	34.4±3 2	33.0±2.0	28.9±7.9	26.7± 6.9	30.8± 8.9	28.9± 7.3
10	36.2±3.5	35.2±2.4	27 5±7.5	26.5± 7.4	30.5± 9.6	29.5± 8.4
Average	35.5±3.2	36.3±2.3	30.5±7.9	29.3± 8.2	32.2± 8.9	31.7± 8.5

The group fed solvent extracted meal gained an average of 83.6 pounds during the experiment while the other group fed expeller meal gained 86.0 pounds.

PALATABILITY

To test the relative palatability of the two feed mixtures fed in both of these trials, small lots of these mixtures were prepared without salt. Four Holstein cows of the Experiment Station herd were offered as much of each mixture in separate pans as they were accustomed to eating. The roughage feeding was alike for all four. The two pans were placed in the mangers simultaneously and left six or seven minutes depending upon the amount of dairy ration fed. Then both pans were removed simultaneously and the refusal weighed. The position of the two pans was alternated from day to day. The average consumption of the two mixtures for 12 days did not indicate any difference in palatability of the two linseed oil meals.

WATER ABSORBING CAPACITY

The height of the water soaked linseed oil meals in the graduated cylinders shown in Figure 4 indicates the ability of each product to absorb water in the digestive tract. The much greater absorptive capacity of the solvent extracted linseed oil meal suggests that it will have the same property in the digestive tract. Ninety milliliters of distilled water were placed in the flask and ten grams of linseed oil meal

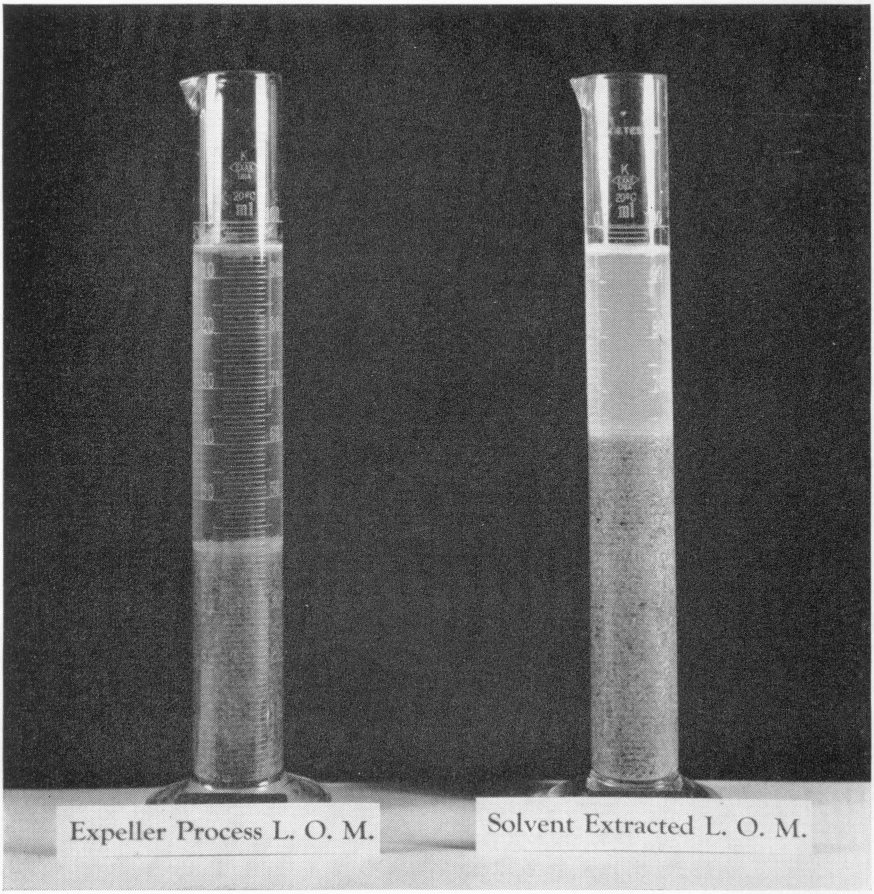

Fig. 4.—The height of the water-soaked meal in the cylinders shows the ability of the various materials to absorb moisture as it would occur in the digestive tract. Solvent extracted meal had the greater absorptive power.

were placed on the top. The solvent extracted meal being freer from fat absorbed water more rapidly and sank sooner to the bottom of the cylinder. The solvent extracted meal, having absorbed more water, was more flocculent and packed less. In the rumen this property should be an asset and should hasten digestion by protein-splitting bacteria although the technique of this feeding experiment provided no opportunity to check this assumption.

In view of this evidence that the factors responsible for the conditioning quality of linseed oil meal remain in the meal even after extraction with hexane, other experiments to study the colloidal gum prepared by the method of Mason and Hall (16) are indicated.

SUMMARY

1. Two feeding trials consisting of two 10-day preliminary periods, a transition period and ten 10-day experimental periods were used to compare solvent extracted and expeller process linseed oil meal.

2. A total of 38 cows in each group produced the same amount of 4 percent (F.C.M.) milk with comparable variations within the two groups.

3. Body weight changes, ratios of grain eaten per pound of 4 percent milk produced and milk production of the two groups further indicate that extraction of linseed meal with hexane does not reduce the feeding value of linseed oil meal when the difference in energy content can be compensated.

4. Solvent extracted linseed oil meal absorbs more water and, consequently, is more flocculent than expeller process linseed oil meal.

5. The hair of cows fed solvent extracted linseed oil meal was as glossy as that of cows fed expeller meal. The cows otherwise showed as good physical condition as those fed expeller meal.

6. The assumption that lower milk production would not occur when solvent extracted linseed oil meal was substituted for expeller process linseed oil meal was tested by application of the "t" test which indicated the same results could be expected 99 times out of 100 if the experiment were repeated.

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